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Checklist of the freshwater shrimps (Crustacea, Decapoda, Caridea) from the Banggai Archipelago, Central Sulawesi, Indonesia

Annawaty Annawaty[1], Nur Hidayah E. Lapasang[1,2], Puji Rahayu[1], Hairul Hairul[1], Fazlur Rahman I. Tadeko[1,3], Diky Dwiyanto[1,4*]

1 Department of Biology, Tadulako University, Palu, Indonesia • AA: annawaty09@gmail.com https://orcid.org/0000-0003-0112-7313 • NHEL: nurhidayahlapasang13@gmail.com • PR: pujir437@gmail.com • HH: hairuljul99@gmail.com • FRIT: maman.tadeko10@gmail.com • DD: dikydwiyanto@gmail.com https://orcid.org/0000-0002-4479-6296

2 Dinas Lingkungan Hidup, Banggai Kepulauan, Indonesia

3 SMA Negeri 1 Bangkurung, Banggai Laut, Indonesia

4 Agrotechnology Study Program, PSDKU Tojo Una-Una, Tadulako University, Ampana, Indonesia

* Corresponding author

Abstract

The mainland of Sulawesi is well known for its high diversity of freshwater shrimps. However, many small islands surrounding Sulawesi have been neglected and have not been unexplored. Here, we report on the freshwater shrimps of the Banggai Archipelago, eastern Sulawesi, based on field collections between 2017 and 2019 on four islands, Peleng, Labobo, Bangkurung, and Banggai. Eleven species were found: *Caridina brevidactyla* J. Roux, 1920, *Caridina brevicarpalis* De Man, 1892, *Caridina gracilipes* De Man, 1892, *Caridina gracilirostris* De Man, 1892, *Caridina serratirostris* De Man, 1892, *Caridina typus* H. Milne Edwards, 1837, *Caridina weberi* De Man, 1892, *Macrobrachium australe* (Guérin-Méneville, 1838), *Macrobrachium equidens* (Dana, 1852), *Macrobrachium lar* (Fabricius, 1798), and *Macrobrachium latidactylus* (Thallwitz, 1891). One species, *C. brevidactyla*, is a newly recorded from Sulawesi. Knowledge of the diversity of the freshwater shrimp fauna can contribute to the conservation of species and their habitats.

Keywords

Amphidromous, Atyidae, eastern Sulawesi, Palaemonidae, taxonomy

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Introduction

Freshwater macroinvertebrates on the oceanic islands are generally dominated by groups of taxa whose larval development is highly dependent on brackish and seawater (see McDowall 2007 for a detailed discussion of amphidromy). This is true for caridean shrimps (Resh et al. 1990; Benstead et al. 2009). Freshwater shrimps are one of the critical components of the freshwater ecosystems of tropical islands (Crowl et al. 2001) and are well known to have an amphidromous life history (Jalihal 1993; Bauer 2013). The presence of freshwater shrimps significantly impact many ecological services, including detrital processing (Pringle et al. 1993; Crowl et al. 2001). Although

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amphidromous shrimps are most abundant in downstream areas (Soomro et al. 2016; Dwiyanto et al. 2018), the distribution of freshwater shrimps is not generally affected by altitude as long as there is direct access to the sea or estuary (Fièfet et al. 2001). On small islands, anthropogenic activities such as damming and land conversion to settlement can indirectly harm freshwater shrimps by limiting their access to estuaries. Among the most highly developed island groups in Sulawesi is the Banggai Archipelago in eastern Sulawesi.

Although the freshwater shrimp fauna on Sulawesi have been well documented for a long time (Hickson 1888; Thallwitz 1891; De Man 1892), there has been limited exploration of it outside the mainland. For example, of the total of 56 species of *Caridina* H. Milne Edwards, 1837 reported from Sulawesi, there are only seven species—*C. butonensis* Klotz & K. von Rintelen, 2013, *C. thomasi* K. von Rintelen, Karge & Klotz, 2008, *C. serratirostris* De Man, 1892, *C. typus* H. Milne Edwards, 1837, *C. weberi* De Man, 1892, *C. brachidactyla* De Man, 1908 (= *C. wyckii* in De Man 1892), and *C. gracilirostris* De Man, 1892—have been known to occur on nearby islands (De Man 1892; von Rintelen et al. 2008; Klotz and von Rintelen 2013).

Sulawesi is also relatively well known as a hotspot for endemic atyid shrimp in Southeast Asia, particularly the genus *Caridina* (von Rintelen and Cai 2009; Klotz and von Rintelen 2013). In contrast Atyidae, only 11 species of Palaemonidae have been reported from Sulawesi, none of which is endemic to the island (De Man 1881; Thallwitz 1891; De Man 1892; Holthuis 1950; Chace and Bruce 1993; Wowor and Ng 2007; Annawaty and Wowor 2015; Rahmi et al. 2016; Dwiyanto et al. 2018; Laewa et al. 2018). Freshwater shrimps from small surrounding islands of Sulawesi still receive little attention, except for three islands, namely Selayar Island, near Makassar (De Man 1892; Holthuis 1950), Peleng Island, near Luwuk Peninsula (von Rintelen et al. 2008), and Buton Island, near Kendari (Klotz and von Rintelen 2013). Inventories of freshwater shrimp biodiversity from many small islands are still lacking, including islands of the Banggai Archipelago in eastern Sulawesi. We report on the presence of freshwater shrimps belonging to the families Atyidae and Palaemonidae in the Banggai Archipelago, Indonesia, and some notes on their ecology and distribution.

Study Area

The Banggai Archipelago, in the eastern part of Sulawesi close to the Luwuk Peninsula (Fig. 1), is a chain of volcanic islands which belong to Banggai–Sula Geological Block. It has been suggested that these Australian fragments arrived during the Miocene to Pliocene (Garrard et al. 1988; Hall 2012). The archipelago is separated from the Sulawesi mainland by a deep strait that has never been connected to the mainland, even during the lowest sea level in the past (Watkinson et al. 2011; Nugraha and

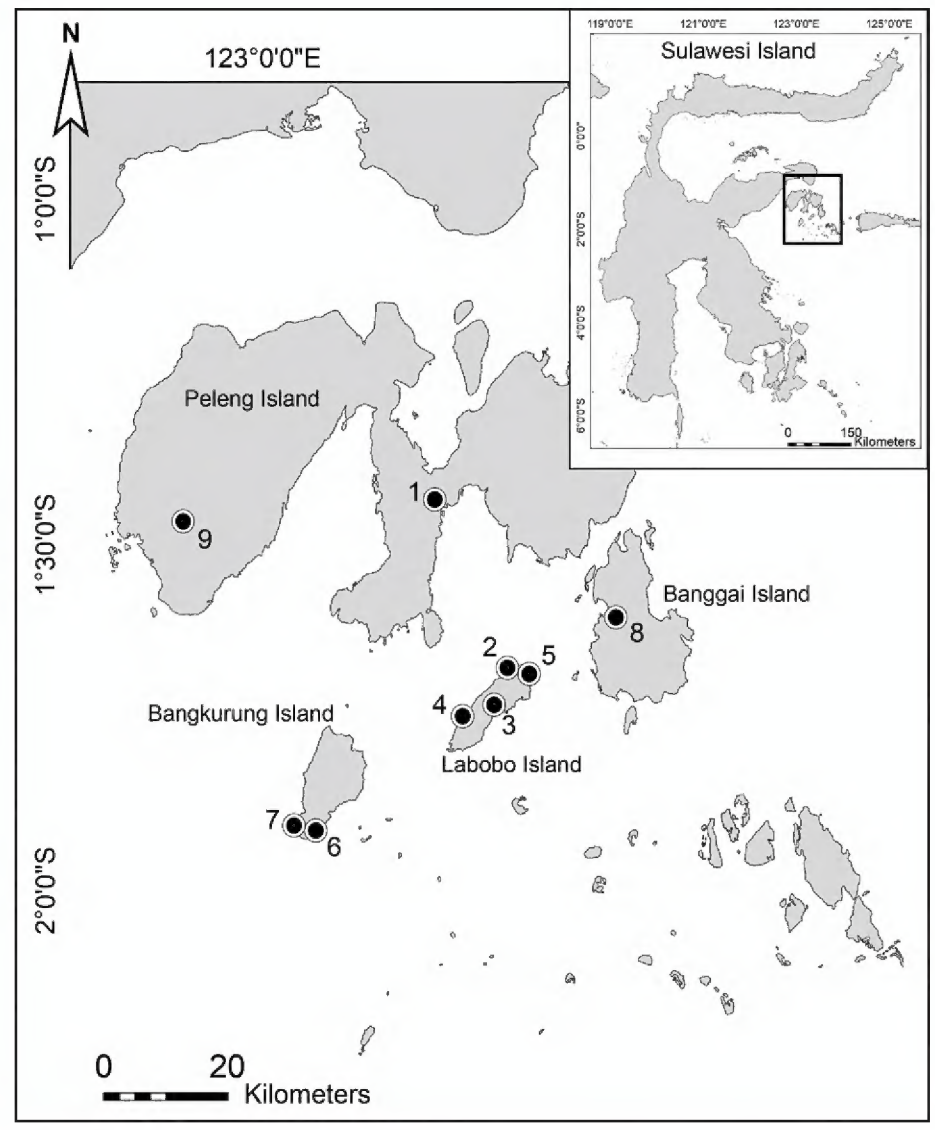

Figure 1. Collection sites of freshwater shrimp from Banggai Archipelago, eastern Sulawesi peninsula: 1 = Sungai Bukoti Mbombol, 2 = Mata Air Batambean, 3 = Mata Air Lipulalongo, 4 = Mata Air Kotukan, 5 = Mata Air Lamo, 6 = Sungai Taduno, 7 = Sungai Kanari, 8 = Sungai Matube, 9 = Alani, type locality of *Caridina thomasi* (von Rintelen et al. 2008).

Hall 2018). Most of the archipelago's islands are formed by metamorphic rock, but their landscapes are dominated by a limestone formation formed during Neogene (Watkinson et al. 2011).

In the Banggai Archipelago, freshwater habitats include several streams (Fig. 2A, B), creeks (Fig. 2C, D), small permanent pools ("mata air" in Indonesian) (Fig. 2E), and even a small lake (Fig. 2F). Some of these freshwater bodies flow directly toward settlements and are used by people (Fig 2B). Many underground rivers connect these water bodies with the sea. The presence of these habitats are vitally important for various faunal elements, not only freshwater fishes (Haryono and Sauri 2020) and invertebrates (including endemic shrimp, *C. thomasi* from the karstic stream in Peleng Island; von Rintelen et al. 2008), but also terrestrial vertebrates like amphibians and reptiles (Riyanto and Rahmadi 2021). Peleng Island, the largest island (2,340 km^2), Banggai Island (294.39 km^2), Bokan Island (229.08 km^2), Bangkurung Island (145 km^2), and Labobo Island (80 km^2) are part of the Banggai Archipelago with their administrative region a part of the Banggai Kepulauan and Banggai Laut Regency.

Methods

Fieldwork and sampling were carried out from March 2017 to February 2019 in eight localities on four islands:

Figure 2. Representatives of freshwater habitat types. **A.** Stream near downstream area with slow water current. **B.** Stream near estuary and mangrove area (Sungai Bukoti Mbombol). **C.** Creek with fast-flowing current (Sungai Kanari). **D.** Creek with slow current (Sungai Taduno). **E.** Small permanent pool (mata air). **F.** Lake-like extension formed from the karstic river (Alani).

Sungai Bukoti Mbombol (Peleng Island), Mata Air Batambean, Mata Air Lipulalongo, Mata Air Kotukan, Mata Air Lamo (Labobo Island), Sungai Kanari, and Sungai Taduno (Bangkurung Island), and Sungai Matube (Banggai Island) (Fig. 1; Table 1). Specimens were caught with a tray net (mesh size 260 µm) and electrofishing (Ng 2017) and preserved in 96% ethanol. After 24 h, the ethanol was replaced with new 96% ethanol for long-term preservation. Environmental variables were taken, including water temperature (°C), dissolved oxygen (DO) (mg/l) (Lutron DO-5509), pH, microhabitat, and substrate.

Identifications of the species were made according to several published monographs, books, and articles, including Chace and Bruce (1993), Chace (1997), Wowor et al. (2004), and de Mazancourt et al. (2020). The rostral formula and characters follow von Rintelen and Cai (2009). Morphological identification was made using Nikon SMZ745T (Japan) stereomicroscopes. Drawings for the specimens of atyids were made using the "digital inking" method (Coleman 2003, 2006) using Adobe Illustrator CC 2018. Due to their large size, specimens of palaemonid shrimp (*Macrobrachium* spp.) were manually drawn by pen on tracing paper based on printout of photographs from a digital camera. Specimens are deposited in the Laboratory of Animal Biosystematics and Evolution, Department of Biology, Tadulako University (UNTAD), Palu, Indonesia (UTD Cru. XXXX), and Museum Zoologicum Bogoriense (MZB), Research Center for Biosystematic and Evolution, National Research

Table 1. Characteristics of sampling sites of freshwater shrimp in four islands (Peleng, Labobo, Bangkurung, and Banggai) in Banggai Archipelago.

Locality	Description
Peleng Island	
Sungai Bukoti Mbombol	Stream near settlement and plantation with slow current, elevation 1–14 m a.s.l., water depth 0.1–2 m, cobble, sand, and mud bottom with shrubs, coconut, sago and cacao trees along the riverbank
Labobo Island	
Mata Air Batambean	Stream with moderate water flow near estuary, elevation 1–12 m a.s.l., water depth ~0.25 m, coarse sand, and mud bottom with shrubs, sago trees, and mangrove forest along riverbank
Mata Air Lipulalongo	Small creek with water flow among and under rocks, elevation 22–27 m a.s.l, water depth ~0.12 m, rocky sand bottom with shrubs, and palm trees along creek bank
Mata Air Kotukan	Small creek with water flow among rocks, elevation 84 m a.s.l., water depth 0.20 m, rocky sand bottom with shrubs, sago, and durian trees along creek bank
Mata Air Lamo	Small creek for drinking water inside the cave, elevation 45 m a.s.l, water depth 0.04 m, mud, and rocky sand bottom
Bangkurung Island	
Sungai Taduno	Small stream near settlement with slow current, elevation 25 m a.s.l, water depth 0.10–0.30 m, sand bottom, with coconut and sago trees along riverbank
Sungai Kanari	Small stream with fast current among rocks into natural pool, elevation 32 m a.s.l, water depth 0.16–0.20 m, sand, mud, leaf litter, and rocky bottom, with shrubs, sago trees, and coconut trees along riverbank
Banggai Island	
Sungai Matube	Stream near settlement and plantation with slow current, elevation 19 m a.s.l, water depth 0.18–2.0 m, mud and sand bottom with shrubs, coconut, and cacao trees along the riverbank

and Innovation Agency (BRIN), Cibinong, Indonesia (MZB Cru. XXXX).

The abbreviations used are: cl = carapace length (in mm; measured from the margin behind the orbit to the posterior edge of the carapace); a.s.l = above sea level; DO = dissolved oxygen; ovig. = ovigerous female; vs. = versus. The Indonesian term "Mata Air" refers to a creek, or freshwater spring formed small permanent pool, and "Sungai" means river, stream, or tributary.

Results

Eleven species were present in our study, classified into seven species from the family Atyidae and four species from the family Palaemonidae (Table 2). One species is recorded as a new record for Sulawesi and nearby islands among these atyid species.

Infraorder Caridea Dana, 1852
Superfamily Atyoidea De Haan, 1849
Family Atyidae De Haan, 1849
Genus *Caridina* H. Milne Edwards, 1837

Table 2. List of species of freshwater shrimps (Atyidae and Palaemonidae) found in Banggai Archipelago, Sulawesi with their respective island. One species, not found by us, is also included from the literature.

Species	Locality (Island)				Source
	Peleng	Bangkurung	Labobo	Banggai	
Family Atyidae					
Genus *Caridina*					
C. brevidactyla †‡				√	ps
C. brevicarpalis †	√				ps
C. gracilipes	√		√		ps
C. gracilirostris	√				ps
C. serratirostris	√	√	√		ps
C. typus		√	√		ps
C. thomasi †	√				§
C. weberi		√	√		ps
Family Palaemonidae					
Genus *Macrobrachium*					
M. australe		√	√		ps
M. equidens	√		√		ps
M. lar		√	√		ps
M. latidactylus	√		√		ps
Total (12 species)	7	5	8	1	

† Only found in one island.
‡ First record from Sulawesi.
ps Present study.
§ From von Rintelen et al. (2008).

Caridina brevidactyla J. Roux, 1920

Figure 3A–F

Material examined. INDONESIA – **Central Sulawesi** • Banggai Island, Sungai Matube; 01°36′26″S, 123° 30′08″E; 19 m elev.; 10.III.2020; Hairul leg.; 3 ♂ (cl 4.26–4.31 mm), 3 ♀ (cl 4.44–6.30 mm), MZB Cru 5358; 10 ♂ (cl 4.26–4.31 mm), 4 ♀ (cl 4.44–6.30 mm), UTD Cru. 0178.

Identification. Rostrum long, upturned, slightly beyond end of antennular peduncle; dorsal margin fully armed or sometimes unarmed distally with 1 or 2 subapical teeth presence, rostral formula: 2–3+24–28+1–2/13–15. Carpus of first pereiopod 2.4–2.8 times as long as wide, chelae 2.4–2.5 times as long as wide, dactylus 1.4–1.5 times as long as propodus. Carpus of second pereiopod about 6.4 times as long as wide, chela 2.9 times as long as wide, dactylus 1.4–1.7 times as long as propodus. Dactylus of third pereiopod with 5 or 6 spiniform setae on flexor margin and ending with one claw. Pre-anal carina low, without a spine. Uropodal diaeresis with 12–15 movable spiniform setae.

Distribution. *Caridina brevidactyla* is known from Indonesia (Cai and Ng 2001; de Mazancourt et al. 2018a), Solomon Islands, Vanuatu, Fiji, and New Caledonia (de Mazancourt et al. 2018a). The type locality of this species is Aru Island, Indonesia (Roux 1920).

Ecology. *Caridina brevidactyla* was found only on Banggai Island. This species occurs in various microhabitats,

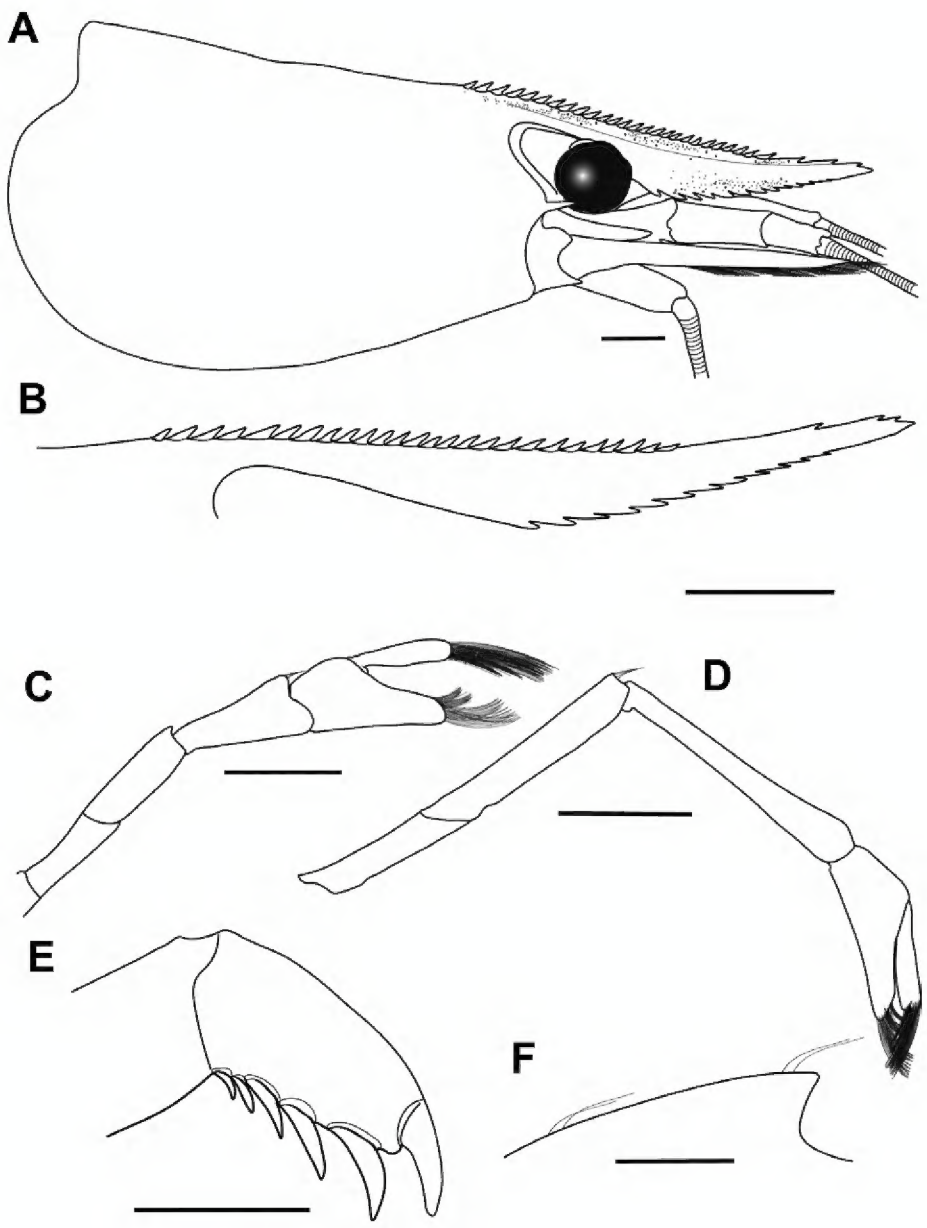

Figure 3. Schematic illustrations of *Caridina brevidactyla* J. Roux, 1920. **A.** Carapace. **B.** Rostrum variation. **C.** First pereiopod. **D.** Second pereiopod. **E.** Dactylus of third pereiopod. **F.** Pre-anal carina. Scale bars: A–D = 1 mm; E, F = 0.2 mm.

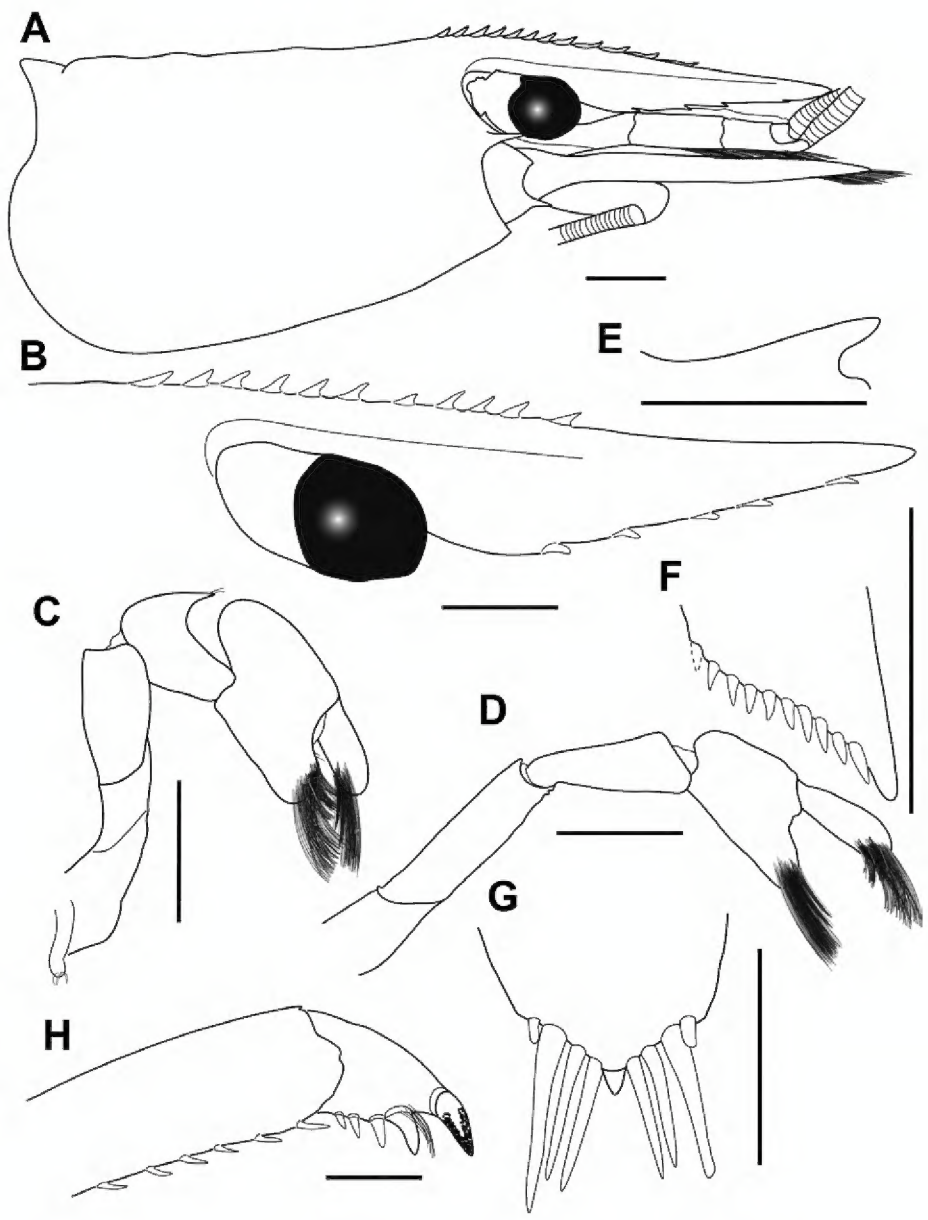

Figure 4. Schematic illustrations of *Caridina brevicarpalis* De Man, 1892. **A.** Carapace. **B.** Rostrum variation. **C.** First pereiopod. **D.** Second pereiopod. **E.** Pre-anal carina. **F.** Diaeresis. **G.** Distal margin of telson. **H.** Dactylus of third pereiopod. Scale bars: A–D = 1 mm; E, H = 0.2 mm; F, G = 0.5 mm.

including in macrophytes and submerged tree roots with mud and sand substrates.

Remarks. Our *C. brevidactyla* material appears to be the first record from Sulawesi and only the third report in Indonesia since Aru Island (Roux 1920) and Halmahera (Cai and Ng 2001). Although Cai and Ng (2001) described *C. brevidactyla* from Halmahera, our specimens fit well with the descriptions of *C. brevidactyla* by de Mazancourt et al. (2018a) based on the rostrum dentition; carpus of first and second pereiopod; spiniform setae of third pereiopod and movable spiniform setae on diaeresis. Our specimens differ from *C. brachydactyla* by the number of teeth on the dorsal margin of the rostrum and pre-anal carina.

Caridina brevicarpalis De Man, 1892

Figure 4A–H

Material examined. INDONESIA – **Central Sulawesi** • Peleng Island, Sungai Bukoti Mbombol; 01°25′02″S, 123°14′24″E; 14 m elev.; 05.III.2017; Nur Hidayah E. Lapasang leg.; 3 ♀ (cl 5.29–6.03 mm), 8 ovig. ♀ (cl 5.77–6.73 mm), MZB Cru 5371; 34 ♂ (cl 3.81–4.84 mm), 13 ♀ (cl 3.75–6.52 mm), 19 ovig. ♀ (cl 0.45–6.57 mm), UTD Cru. 0024.

Identification. Rostrum long, beyond end of antennular peduncle, without apical tooth, 0.7–0.9 times as long as carapace, with rostral formula: 1+10–14/4–7. Carpus of first pereiopod deeply excavated, 1.0–1.1 times as long as wide; chelae 1.7–1.9 times as long as wide; dactylus 0.6–0.8 times as long as propodus. Carpus of second pereiopod more slender, about 2.6–2.8 times as long as wide; chela 2.0–2.2 times as long as wide; dactylus 0.9–1.2 times as long as propodus. Third pereiopod with propodus 7.0–7.6 times as long as wide, 3.7–4.0 times as long as dactylus; dactylus of third pereiopod with 4 spiniform setae on flexor margin and ending with 1 claw. Pre-anal carina high, armed with a spine. Telson with 5 or 6 pairs of spiniform setae dorsally; distal margin of telson with posteromedian projection, lateral pair of spiniform setae longer than intermediate pairs. Uropodal diaeresis with 8–10 movable spiniform setae.

Distribution. *Caridina brevicarpalis* has a wide distribution in the Pacific, from the Philippines (Cai and Shokita 2006) and Indonesia (Sulawesi) to Fiji (Marquet et al. 2002).

Ecology. *Caridina brevicarpalis* was only found in Sungai Bukoti Mbombol and collected from the root of macrophytes on mud and sand substrates. Dissolved oxygen (DO) wa 4.34–6.98 mg/l, pH was 7, and the water current was very slow to moderate.

Remarks. De Man (1892) reported *C. brevicarpalis* from Palopo, Sulawesi Selatan. This species has also been previously reported from Donggala, Central Sulawesi (Dwiyanto et al. 2018). The specimens from Sungai Bukoti

Mbombol, Banggai Kepulauan, fit well with the description of *C. brevicarpalis* by De Man (1892), based on the main character, which is that the carpus of the first pereiopod is deeply excavated (Fig. 4C). This species differs from another closely related species, *C. barakoma* de Mazancourt, Boseto, Marquet & Keith, 2020 from Solomon Island (de Mazancourt et al. 2020), by the rostrum armature and the propodus of the third pereiopod. Although based on the presence of one tooth behind the orbital margin, which made the specimens more resemble *C. endehensis* De Man, 1892, our specimens can be distinguished from *C. endehensis* by the dentition and shape of the rostrum that never reach far beyond the antennal scale (Chace 1997).

Caridina gracilipes De Man, 1892

Figure 5A–H

Material examined. INDONESIA – **Central Sulawesi** • Peleng Island, Sungai Bukoti Mbombol; 01°25′00″S, 123°14′30″E; 13 m elev.; 05.III.2017; Nur Hidayah E. Lapasang leg.; 1 ♂ (cl 4.24 mm), 1 ♀ (cl 6.03 mm), 4 ovig. ♀ (cl 4.20–4.91 mm), MZB Cru. 5372; 15 ♂ (cl 3.51–4.34 mm), 10 ♀ (cl 3.31–5.57 mm), 3 ovig. ♀ (cl 4.47–6.07 mm), UTD Cru. 0026 – **Central Sulawesi** • Labobo Island, Mata Air Batambean; 01°40′42″S, 123°21′28″E; 13 m elev.; 22.II.2019; Puji Rahayu, Annawaty leg.; 1 ♂ (cl 3.21 mm), 4 ♀ (cl 2.91–3.41 mm), 2 ovig. ♀ (cl 2.93–4.29 mm), UTD Cru. 0127.

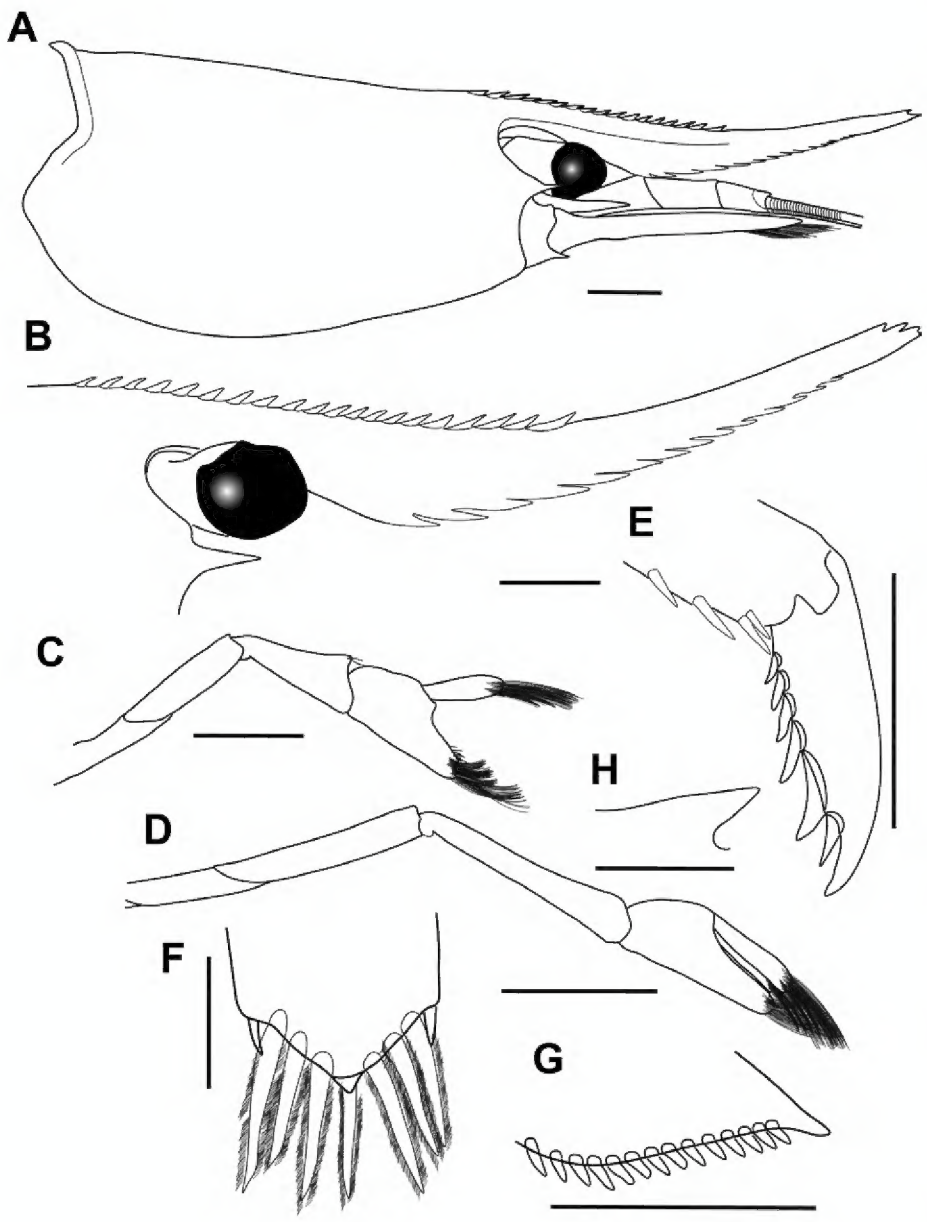

Figure 5. Schematic illustrations of *Caridina gracilipes* De Man, 1892. **A.** Carapace. **B.** Rostrum variation. **C.** First pereiopod. **D.** Second pereiopod. **E.** Dactylus of third pereiopod. **F.** Distal margin of telson. **G.** Diaeresis. **H.** Pre-anal carina. Scale bars: A–D = 1 mm; E, F, H = 0.2 mm; G = 0.5 mm.

Identification. Rostrum long, extending far beyond the end of the antennular peduncle, upturned anteriorly, 1.2–1.7 times as long as carapace; rostral formula: 2+9–18+1–2/13–19, apical teeth present. Carpus of first pereiopod shorter than chelae, 2.2–2.4 times as long as wide; chelae 2.2–2.5 times as long as wide; dactylus 1.0–1.1 times as long as propodus. Carpus of second pereiopod more slender, longer than chelae, about 5.6 times as long as wide; chela 2.4–2.5 times as long as wide; dactylus 1.0–1.5 times as long as propodus. Third pereiopod with propodus 3.6 times as long as dactylus; dactylus of third pereiopod with 4–6 spiniform setae on flexor margin and ending with 1 claw. Pre-anal carina high, armed with a spine. Telson with 4 or 5 pairs of spiniform setae dorsally; distal margin of telson with posteromedian projection. Uropodal diaeresis with 10–13 movable spiniform setae.

Distribution. *Caridina gracilipes* is distributed in southern China (Cai 2020), Taiwan, the Philippines, and Indonesia (Sulawesi and Borneo) (Cai and Shokita 2006).

Ecology. From Sungai Bukoti Mbombol, we found *C. gracilipes* in several microhabitats, including submerged sago, coconut roots, and macrophytes. This species was found together with other atyids, including *C. serratirostris*, *C. typus*, *C. brevicarpalis*, and one palaemonid shrimp, *Macrobrachium latidactylus*. At Mata Air Batambean, *C. gracilipes* was collected under leaf litter, dead wood, and macrophytes together with the palaemonids *M. australe*, *M. equidens*, and *M. latidactylus*. This species was found in an area with slow to moderate water current and with rock and mud substrates. The water was 26–28 °C, had DO of 4.34–8.80 mg/l, and a pH of 7.0–8.2.

Remarks. *Caridina gracilipes* was first described from Luwu, Palopo, South Sulawesi (De Man 1892). Dwiyanto et al. (2018) reported *C. gracilipes* from Batusuya River, Donggala, Central Sulawesi. Our specimens of *C. gracilipes* agree well with the descriptions of this species by De Man (1892) as *C. wiicky* var. *gracilipes*.

Caridina gracilirostris De Man, 1892

Figure 6A–E

Material examined. INDONESIA – **Central Sulawesi** • Peleng Island, Sungai Bukoti Mbombol; 01°25′02″S, 123°14′24” E; 14 m elev.; 05.III.2017; Nur Hidayah E. Lapasang leg.; 2 ♂ (cl 4.13–4.28 mm), MZB Cru 5373 (ex UTD Cru. 0027).

Identification. Rostrum very long, reaching far beyond end of antennular peduncle and slightly upturned anteriorly, 1.6 times as long as carapace, with rostral formula: 2+6–7/36–39. First pereiopod with carpus about 1.9 times as long as wide; chelae 2.3 times as long as wide; dactylus 1.0 times as long as propodus. Carpus of second pereiopod more slender, about 4.6 times as long as wide; chela 2.3 times as long as wide; dactylus 1.3 times as

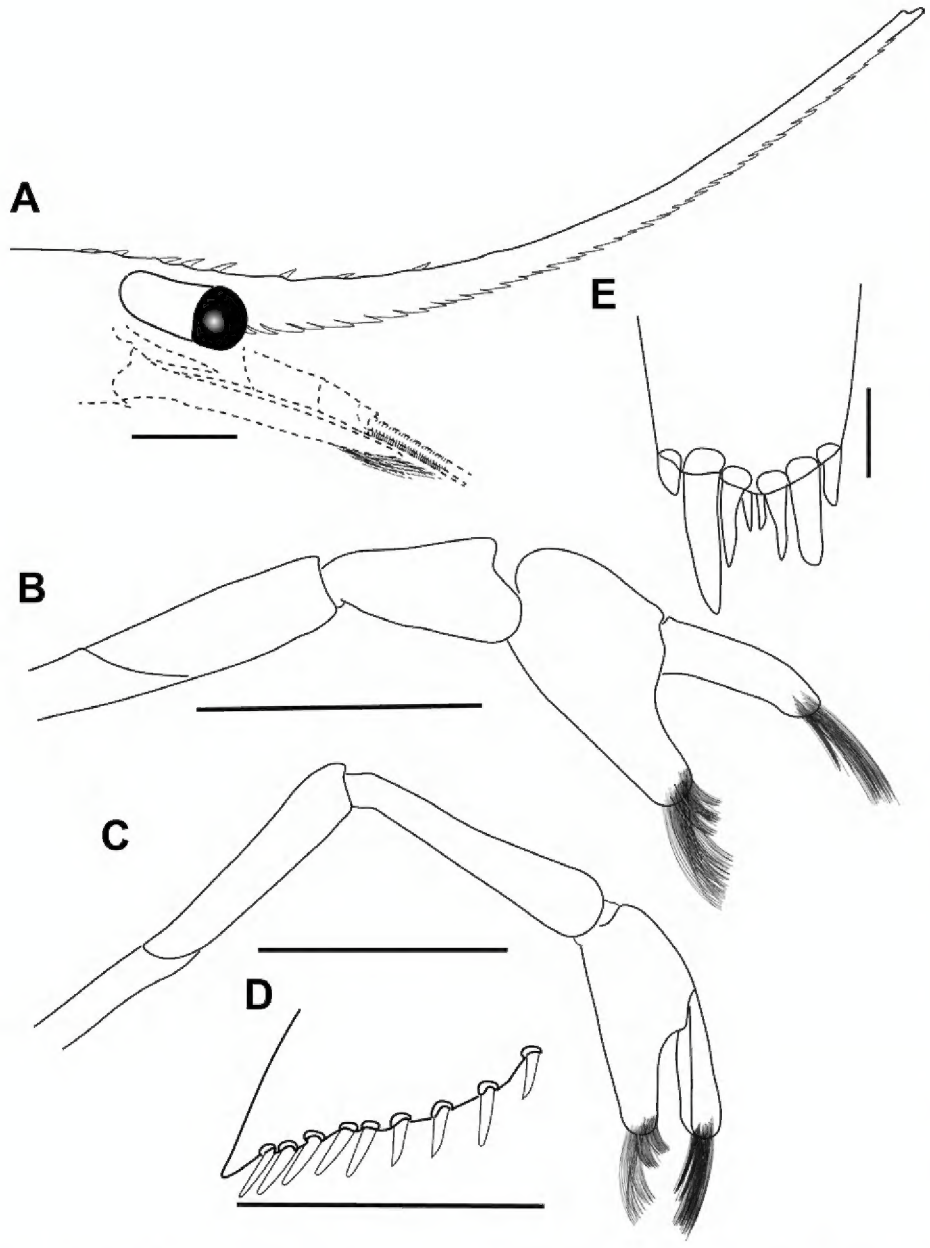

Figure 6. Schematic illustrations of *Caridina gracilirostris* De Man, 1892. **A.** Rostrum shape. **B.** First pereiopod. **C.** Second pereiopod. **D.** Diaeresis. **E.** Distal margin of telson. Scale bars: A–C = 1 mm; D = 0.5 mm; E = 0.1 mm.

long as propodus. Endopod of male first pleopod without appendix interna. Telson with 4 pairs of dorsal spiniform setae; distal margin of telson without posteromedian projection. Pre-anal carina armed with a spine. Uropodal diaeresis with 8 or 9 movable spiniform setae.

Distribution. *Caridina gracilirostris* is widely distributed in the Indo-Pacific from Madagascar, India, China, Taiwan, Japan, and Indonesia (Sulawesi) (Cai and Ng 2007) to the Solomon Islands and Australia (de Mazancourt et al. 2020).

Ecology. We found *C. gracilirostris* only at Sungai Bukoti Mbombol, Peleng Island, under dead midribs of sago and macrophytes. This species was found with two other atyids, *C. serratirostris* and *C. brevicarpalis*, and one palaemonid, *M. latidactylus*. The water temperature was 26 °C, DO was 5.44–5.55 mg/l, and the pH was 7.0. Substrates were mixed mud and sand, and there was a slow water current.

Remarks. De Man (1892) noted that *C. gracilirostris* from Sulawesi has a relatively short carpus compared to specimens from Flores. Cai and Ng (2007) revalidated the differences and mentioned that the specimens from Maros and Balangnipa, South Sulawesi also have a short carpus. Our specimens of *C. gracilirostris* are quite similar to those redescribed by Cai and Ng (2007) from South Sulawesi. Our specimens are distinguished from *C. neglecta* Cai & Ng, 2007, which is also described from South Sulawesi (Cai and Ng 2007), by the absent of an appendix interna on the endopod of the male first pleopod.

Caridina serratirostris De Man, 1892

Figure 7A–C

Material examined. INDONESIA – **Central Sulawesi** • Peleng Island, Sungai Bukoti Mbombol; 01°25′00″S, 123°14′30″E; 13 m elev.; 05.III.2017; Nur Hidayah E. Lapasang leg.; 2 ♀ (cl 3.49–3.83 mm), 3 ovig. ♀ (cl 2.50–3.67 mm), MZB Cru. 5374; 17 ♂ (cl 2.46 mm–3.91 mm), 23 ♀ (cl 2.87–4.77 mm), 51 ovig. ♀ (cl 2.81–4.57 mm), UTD Cru. 0025 – **Central Sulawesi** • Bangkurung Island, Sungai Kanari; 01°54′54″S, 123°03′06″E; 32 m elev.; 22.VIII.18; Fazlur Rahman I. Tadeko leg.; 9 ♂ (cl 2.36–2.89 mm), 12 ♀ (cl 2.35–3.68 mm), 13 ovig. ♀ (cl 2.7–4.67 mm), UTD Cru. 149 – **Central Sulawesi** • Bangkurung Island, Sungai Taduno; 01°55′21″S, 123°03′48″E; 25 m elev.; 22.VI.18; Fazlur Rahman I. Tadeko leg.; 4 ♀ (cl 3.60–4.18 mm), 8 ovig. ♀ (cl 3.5–4.81 mm), UTD Cru 0150 – **Central Sulawesi** • Labobo Island, Mata Air Lipulalongo; 01°43′39″S, 123°20′15″E; 22 m elev.; 23.II.19; Puji Rahayu, Annawaty leg.; 1 ♂ (cl 2.31 mm), UTD Cru 0129.

Identification. Rostrum straight, reaching end of antennular peduncle, downwards anteriorly, 0.4–0.6 times as long as carapace; rostral formula: 7–9+13–16/4–7, tip without apical tooth. Carpus of first pereiopod slender, 4.2–5.7 times as long as wide; chelae 2.4–3.4 times as long as wide; dactylus 1.1–1.2 times as long as propodus.

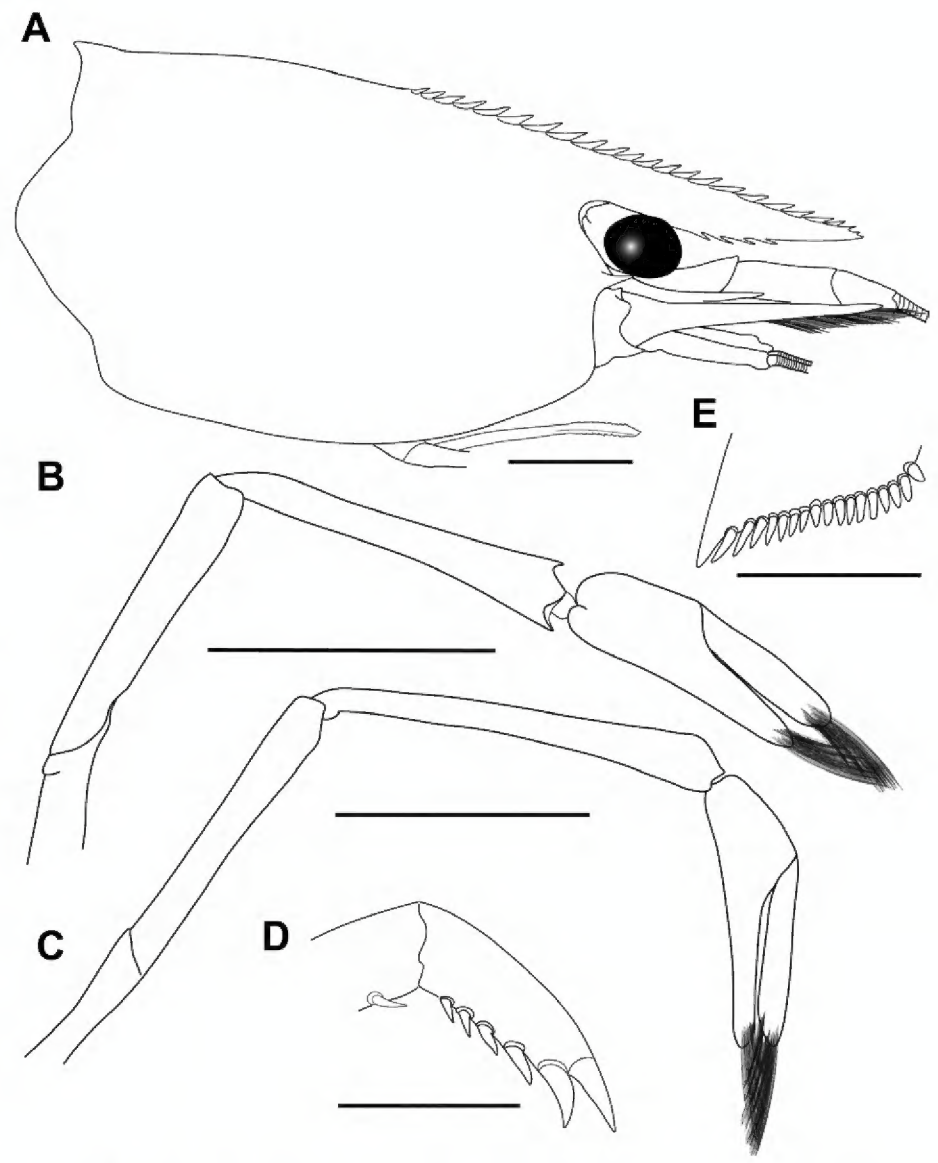

Figure 7. Schematic illustrations of *Caridina serratirostris* De Man, 1892. **A.** Carapace. **B.** First pereiopod. **C.** Second pereiopod. **D.** Dactylus of third pereiopod. **E.** Diaeresis. Scale bars: A–C = 1 mm; D = 0.2 mm; E = 0.5 mm.

Carpus of second pereiopod very slender, longer than chelae, about 8.0–11.0 times as long as wide; chela 3.5–5.0 times as long as wide; dactylus 1.1–1.8 times as long as propodus. Third pereiopod with 5 spiniform setae on flexor margin and ending with one claw. Pre-anal carina with a spine. Telson with 4–5 pairs of spiniform setae dorsally. Uropodal diaeresis with 16–18 movable spiniform setae.

Distribution. *Caridina serratirostris* is distributed in South Africa, Madagascar, Mozambique (Richard and Clark 2010), Japan, Fiji, the Philippines, Malaysia, Indonesia (Sulawesi) (Cai and Shokita 2006), and the Solomon Islands in the Pacific (de Mazancourt et al. 2020).

Ecology. At Sungai Bukoti Mbombol, *C. serratirostris* was found with *C. brevicarpalis*, *C. gracilipes*, *C. typus*, *Macrobrachium latidactylus*, and *M. equidens*. The specimens were collected from sago roots and macrophytes on mixed sand and mud substrates. These species were also found in Sungai Taduno and Kanari under rocks, leaf litter, moss, and macrophytes. This species was collected with *C. weberi*, *C. typus*, *M. lar*, and *M. australe*. At Mata Air Batambean, the water temperature was 24–27 °C, DO was 4.34–8.60 mg/l, and pH was 7.0–9.6; the current was very slow, almost stagnant.

Remarks. *Caridina serratirostris* was first described by De Man (1892) based on type specimens from Luwu, near Palopo, South Sulawesi. This species mostly resembles *Caridina celebensis* De Man, 1892 but can be differentiated by the presence or absence of arthrobranch on the first pereiopod (ranging from visible to barely visible in *C. serratirostris* vs. totally absent in *C. celebensis*; Cai and Shokita 2006). Our specimens have an arthrobranch that is distinctly visible, thus confirming that they are *C. serratirostris*.

Caridina thomasi K. von Rintelen, Karge & Klotz, 2008

Figure 8A, B

Material examined. Not found in this study.

Identification. Rostrum short, unarmed, not reaching to basal segment of antennular peduncle, 0.2–0.3 times as long as carapace. Carpus of first pereiopod 1.4–1.9 times as long as wide; chelae 1.8–2.1 as long as wide; dactylus 0.7–2.0 times as long as propodus. Carpus of second pereiopod more slender and longer than first pereiopod, 3.8–5.4 times as long as wide; chelae 2.2–2.8 times as long as wide, dactylus 1.0–1.8 times as long as propodus. Propodus of third pereiopod 3.9–4.7 times as long as dactylus; dactylus with 5–7 spiniform setae on flexor margin and ending with 1 large claw. Telson with 3–5 pairs of spiniform setae dorsally and 1 pair of dorsolateral, distal margin of telson rounded without median projection. Uropodal diaeresis with 13–15 movable spiniform setae. Pre-anal carina low and rounded, without spine (von Rintelen et al. 2008).

Distribution. *Caridina thomasi* has been reported only from Peleng Island, Banggai Archipelago, Sulawesi, and probably is endemic to the island (von Rintelen et al. 2008).

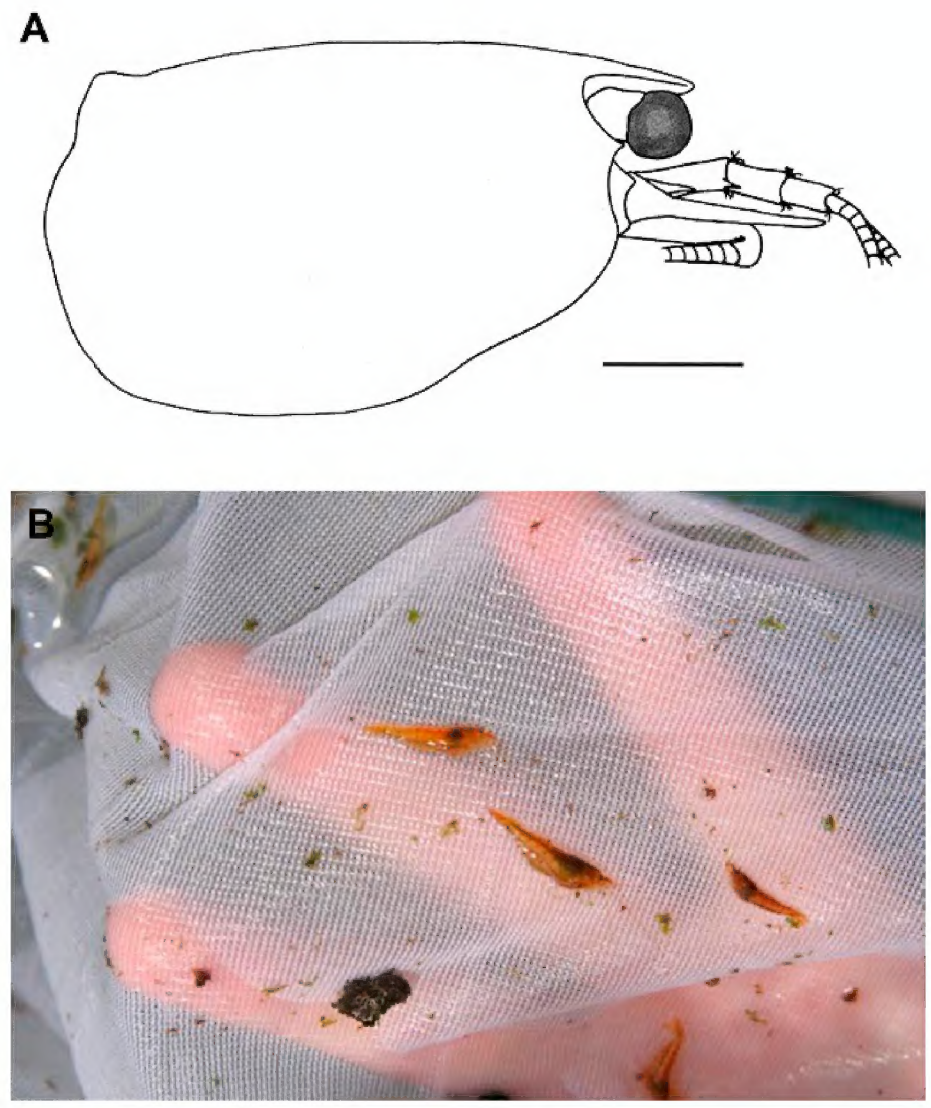

Figure 8. *Caridina thomasi* K. von Rintelen, Karge & Klotz, 2008. **A.** Rostrum. **B.** Colour of live specimens. Scale bar: A = 1 mm (drawing and photograph courtesy of K. von Rintelen, MfN Berlin).

Ecology. This species is found from a river in the karst area (ca. 370 m a.s.l.) near Alani, Bulagi Selatan, Peleng Island. It is most abundant and shelters under rocks along the river's edge. The river bed consists of rocks and almost lacks vegetation (von Rintelen et al. 2008).

Remarks. *Caridina thomasi* is similar to *C. typus*, but it can be easily distinguished by its egg size, rostrum denticulation, and reduced gill formula. According to von Rintelen et al. (2008), *Caridina thomasi* has a unique character that has not been reported in any other *Caridina* species; the arrangement of spines on the merus of the third and fourth pereiopod. The phylogenetic analysis of *C. thomasi* based on 16S mitochondrial DNA placed this species with other *Caridina* species (von Rintelen et al. 2008). However, when nuclear markers are involved, such as 28S and H3, this species is closely related to another cavernicolous genus, *Edoneus* Holthuis, 1978, from the Philippines, which shows the possible need of further systematic revision (von Rintelen et al. 2012).

Caridina typus H. Milne Edwards, 1837

Figure 9A–G

Material examined. INDONESIA – **Central Sulawesi** • Bangkurung Island, Sungai Taduno; 01°43′56″S, 123° 18′17″E; 25 m elev.; 22.VI.18; Fazlur Rahman I. Tadeko leg.; 1 ♀ (cl 4.07 mm), MZB Cru. 5376 – **Central Sulawesi** • Labobo Island, Sungai Mata Air Kotukan; 01°43′56″S, 123°18′17″E; 84 m elev.; 22.II.19; Puji Rahayu, Annawaty leg.; 20 ♂ (cl 3.02–4.71 mm), 63 ♀ (cl 3.12–5.31 mm), 11 ovig. ♀ (cl 4.34–4.51 mm), UTD Cru

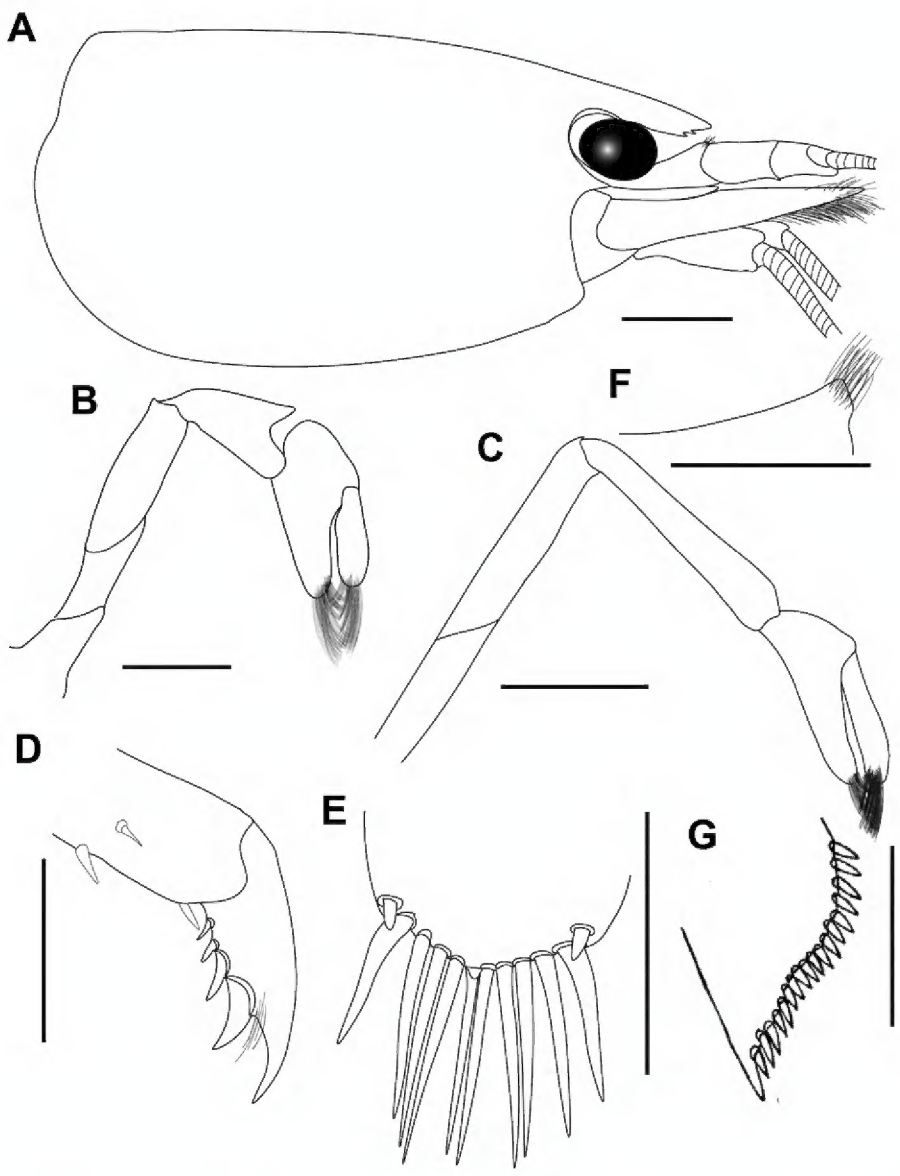

Figure 9. Schematic illustrations of *Caridina typus* H. Milne Edwards, 1837. **A.** Rostrum. **B.** First pereiopod. **C.** Second pereiopod. **D.** Dactylus of third pereiopod. **E.** Distal margin of telson. **F.** Pre-anal carina. **G.** Diaeresis. Scale bars: A–C = 1 mm; D, F = 0.2 mm; E, G = 0.5 mm.

0133 – **Central Sulawesi** • Labobo Island, Sungai Mata Air lamo; 01°40′55″S, 123°22′52″E; 45 m elev.; 22.II.19; Puji Rahayu, Annawaty leg.; 6 ♂ (cl 4.32–5.40 mm), 6 ♀ (cl 3.26–4.85 mm), 8 ovig. ♀ (cl 4.64–6.07 mm), UTD Cru 0135.

Identification. Rostrum short, reaching nearly end of second segment of antennular peduncle, dorsal margin unarmed, armed ventrally with 1–3 teeth. Carpus of first pereiopod excavated anteriorly, 1.2–1.9 times as long as wide; chelae 1.9 times as long as wide; dactylus 1.0 times as long as propodus. Carpus of second pereiopod more slender and longer than first pereiopod, about 5.0 times as long as wide; chela 4.0 times as long as wide; dactylus 1.2 times as long as propodus. Propodus of third pereiopod about 5.0 times as long as dactylus with 5 spiniform setae on flexor margin and ending with 1 claw. Pre-anal carina high, not armed with a spine. Telson with 4 pairs of spiniform setae dorsally. Uropodal diaeresis with 18 movable spiniform setae.

Distribution. *Caridina typus* is one of the most widely distributed species in the Indo-West Pacific, occurring from South Africa to the Solomon Islands in the Pacific (de Mazancourt et al. 2020).

Ecology. We found *C. typus* on Bangkurung and Labobo islands. It was collected from macrophytes and under leaf litter together with *C. weberi* and *M. lar*. In another site, Mata Air Lamo, *C. typus* was collected under rocks together with *M. lar*. The water temperature was 27–28 °C, DO was 7.7–8.8 mg/l, and pH was 9.3–9.7. Substrates were sand and mud.

Remarks. *Caridina typus* was initially described from Mauritius Island by H. Milne Edwards (see Marquet et al. 2002). This species was reported in Sulawesi (Selayar Island and several locations in South Sulawesi) for the first time by De Man (1892). Another record was added by Cai and Ng (2009), who found this species in Maros, South Sulawesi. Morphologically, *C. typus* collected in our study significantly resembles specimens reported by De Man (1892) from Flores and Sulawesi and the specimens from Japan studied by Cai et al. (2006) based on the shape and number of ventral teeth on the rostrum (1–3 vs. 1–4; Cai et al. 2006).

Caridina weberi De Man, 1892

Figure 10A–F

Material examined. INDONESIA – **Central Sulawesi** • Bangkurung Island, Sungai Kanari; 01°54′54″S, 123°03′06″E; 32 m elev.; 22.VI.18; Fazlur Rahman I. Tadeko leg.; 2 ♀ (cl 4.36–5.84 mm), MZB Cru. 5377; 1 ♂ (cl 5.34 mm), 1 ovig. ♀ (cl 4.38 mm), UTD Cru. 0148 – **Central Sulawesi** • Labobo Island, Mata Air Kotukan; 01°43′56″S, 123°18′17″E; 84 m elev.; 22.II.19; Puji Rahayu, Annawaty leg.; 1 ♀ (cl 4.93 mm), 2 ovig. ♀ (cl 4.61–5.04 mm), UTD Cru 0132.

Identification. Rostrum short, 0.4 times as long as carapace length, reaching beyond end of basal segment of

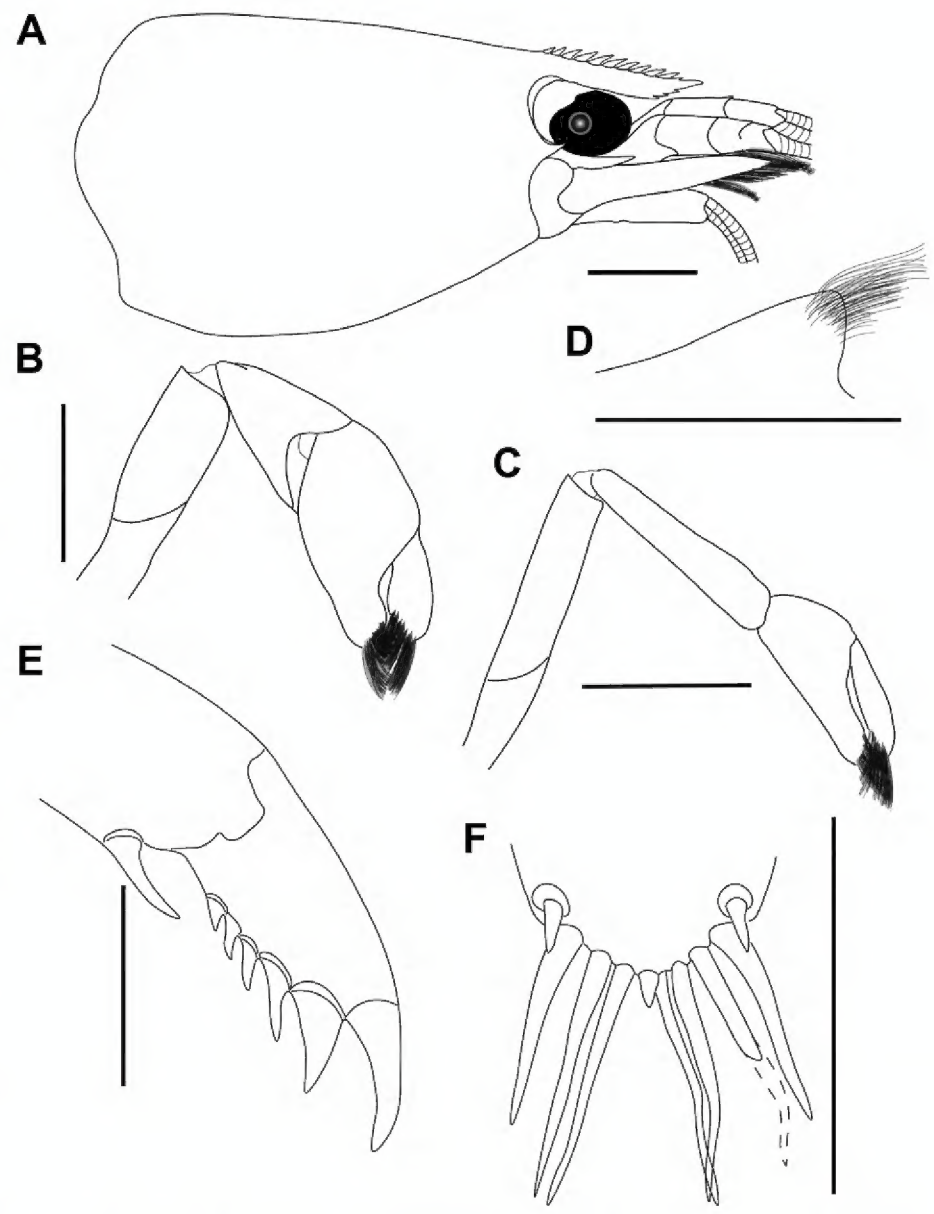

Figure 10. Schematic illustrations of *Caridina weberi* De Man, 1892. **A.** Carapace. **B.** First pereiopod. **C.** Second pereiopod. **D.** Pre-anal carina. **E.** Dactylus of third pereiopod. **F.** Distal margin of telson. Scale bars: A–C = 1 mm; D, F = = 0.5 mm; E = 0.2 mm.

antennular peduncle, dorsal margin armed with 10–15 teeth, 0–1 on carapace, armed ventrally with 3 teeth. Carpus of first pereiopod excavated anteriorly, 1.4 times as long as wide; chelae 2.0 as long as wide. Carpus of second pereiopod more slender, 1.1 times as long as chelae, 4.5 as long as wide. Propodus of third pereiopod slender, with 5 spiniform setae on flexor margin and ending with 1 claw. Pre-anal carina high, not armed with a spine. Telson with 5 or 6 pairs of spiniform setae dorsally, and 1 pair of dorsolateral; distal margin with median process, with 5 intermediate long spiniform setae between 1 pair of lateral spiniform setae.

Distribution. *Caridina weberi* is distributed in Sulawesi, Flores, and Halmahera, Indonesia (Cai and Ng 2001; Dwiyanto et al. 2021), Papua New Guinea, and the Solomon Islands (de Mazancourt et al. 2020). In Sulawesi, this species has been reported from Selayar Island, outside of mainland Sulawesi.

Ecology. We only collected *C. weberi* from Bangkurung and Labobo islands. This species was found with *C. serratirostris* and *C. typus*, and the palaemonid *M. lar*. The microhabitat of this species was under rocks, macrophyte roots, and submerged tree roots at the margin of the water. The water temperature was 27 °C, DO was 7.7 mg/l, and pH was 9.3. Substrates were leaf litter, mud, and rocky sand.

Remarks. Cai and Ng (2001) reported on the specimens from Halmahera, which are quite similar to De Man's (1892) type specimens of *C. weberi* from Kotting, Flores. Cai and Ng (2001) tentatively assigned their specimens to C. *weberi* cf. De Man (1892). The integrative taxonomic study by de Mazancourt et al. (2018b) revised some of the species allied to the *C. weberi* species complex and described three new species, *C. futunensis* de Mazancourt, Marquet & Keith, 2019, *C. marquesensis* de Mazancourt, Marquet & Keith, 2019, and *C. tupaia* de Mazancourt, Marquet & Keith, 2019. These new species differ from *C. weberi* cf. De Man (1892) with respect to morphology and rostrum dentition, carpus of the first and second pereiopod, and distal margin of the telson (de Mazancourt et al. 2018b). Our specimens are more similar to those of Cai and Ng (2001) in their rostrum dentition.

Infraorder Caridea Dana, 1852
Superfamily Palaemonoidea Rafinesque, 1815
Family Palaemonidae Rafinesque, 1815
Genus *Macrobrachium* Spence Bate, 1868

***Macrobrachium australe* (Guérin-Méneville, 1838)**
Figure 11A–F

Material examined. INDONESIA – **Central Sulawesi** • Bangkurung Island, Sungai Kanari; 01°54′54″S, 123° 03′06″E; 32 m elev.; 22.VI.18; Fazlur Rahman I. Tadeko leg.; 1 ♂ (cl 8.40 mm), MZB Cru. 5378 – **Central Sulawesi** • Labobo Island, Mata Air Batambean; 01°40′42″S, 123°21′28″E; 13 m elev.; 22.II.2019; Puji Rahayu, Annawaty leg.; 14 ♂ (cl 4.80–9.48 mm), 3 ♀ (cl 5.41–5.90 mm), 2 ovig. ♀ (cl 8.65–8.69 mm), UTD Cru. 0125.

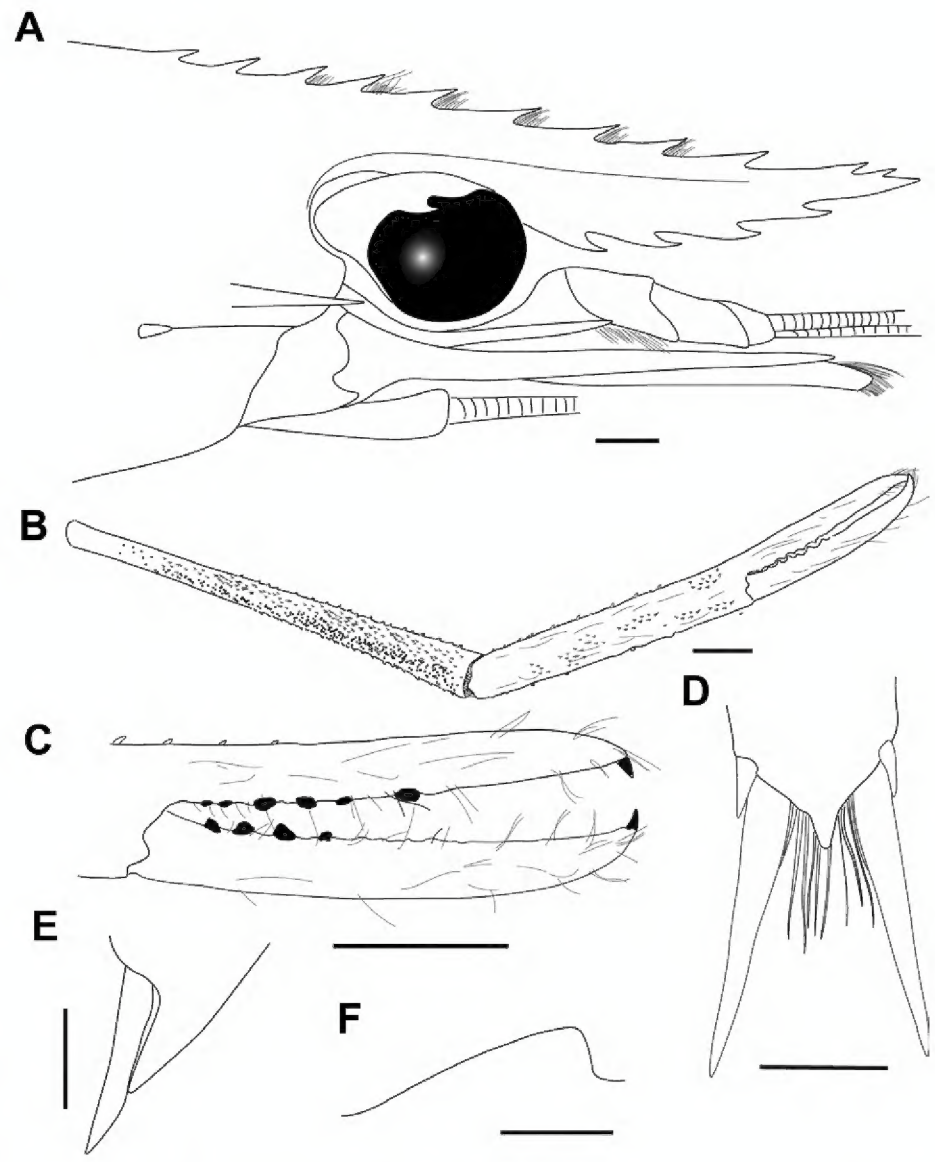

Figure 11. Schematic illustrations of *Macrobrachium australe* (Guérin-Méneville, 1838). **A.** Carapace. **B.** Major second pereiopod. **C.** Finger of major second pereiopod. **D.** Distal margin of telson. **E.** Mobile mesial spine. **F.** Pre-anal carina. Scale bars: 1 mm.

Identification. Rostrum upturned anteriorly, moderately long, distinctly beyond end of scaphocerite, rostral formula: 3+6–8/4; tip with 1 or 2 apical teeth; teeth on carapace evenly spaced. Post-antennular carapace margin straight or almost straight. Second pereiopod long, unequal in size, dissimilar in shape; carpus shorter than chelae but longer than palm; all segments covered with spines and spinules; fingers with 4 or 5 teeth on proximal of cutting edges. Movable spiniform setae on uropodal diaeresis longer than outer angle. Distal margin of telson with one pair of large spiniform setae. Pre-anal carina low without a spine.

Distribution. *Macrobrachium australe* is widely distributed in the Indo-West Pacific including Reunion (Zimmermann et al. 2012). In Indonesia, this species has been reported from Flores, as *Palaemon dispar* von Martens, 1868 (De Grave and Fransen 2011), Halmahera (Cai and Ng 2001), and Tinombo and Donggala, Sulawesi (Rahmi et al. 2016; Dwiyanto et al. 2018).

Ecology. We found *M. australe* only on Labobo and Bangkurung islands. This species was collected together with other palaemonids, including *M. equidens*, *M. lar*, and *M. latidactylus*, and the atyids, *C. serratirostris*, *C. typus*, and *C. weberi*. The microhabitats of this species included macrophytes, leaf litter, and deadwood. The water temperature was 27–28 °C, DO was 8.8 mg/l, and pH was 8.2–8.3; substrates were leaf litter mud and sand.

Remarks. Castelin et al. (2017) studied *M. australe* and

its supposed junior synonym, *M. ustulatum* (Nobili, 1899), from throughout its distribution and determined that they are two distinct species. One of the characteristics used to separate these taxa is the proportions of the joints of the male second pereiopod; in *M. australe* the carpus is 0.78–0.97 times as long as the chelae (vs. 0.68–0.73 in *M. ustulatum*) and 1.18–1.40 times as long as the palm (vs. 1.00– 1.12 in *M. ustulatum*) (Castelin et al. 2017). Our specimens have the carpus 0.80 times as long as the chelae and 1.40 times as long as the palm, which shows that they belong to *M. australe*. *Macrobrachium australe* has also been known for its variation in the shape of the rostrum (Cai and Ng 2001). Zimmermann et al. (2012) has shown that the shape of the rostrum is highly variable between those populations that inhabit in lentic (rostrum long and slender) and lotic waters (rostrum short and broad).

***Macrobrachium equidens* (Dana, 1852)**

Figure 12A–F

Material examined. INDONESIA – **Central Sulawesi** • Peleng Island, Sungai Bukoti Mbombol; 01°25′00″S, 123°14′30″E; 13 m elev.; 05.III.2017; Nur Hidayah E. Lapasang leg.; 2 ♂ (cl 7.77–8.83 mm), MZB Cru 5379; 2 ♂ (cl 7.27–8.66 mm), 2 ♀ (cl 5.37–10.59 mm), UTD Cru. 0028 – **Central Sulawesi** • Labobo Island, Mata Air Batambean; 01°40′42″S, 123°21′28″E; 13 m elev.; 22.II.2019; Puji Rahayu, Annawaty leg.; 38 ♂ (cl 2.73–14.42 mm), 32 ♀ (cl 2.81–12.83 mm), 2 ovigerous ♀ (cl 2.94–6.10 mm), UTD Cru. 0124.

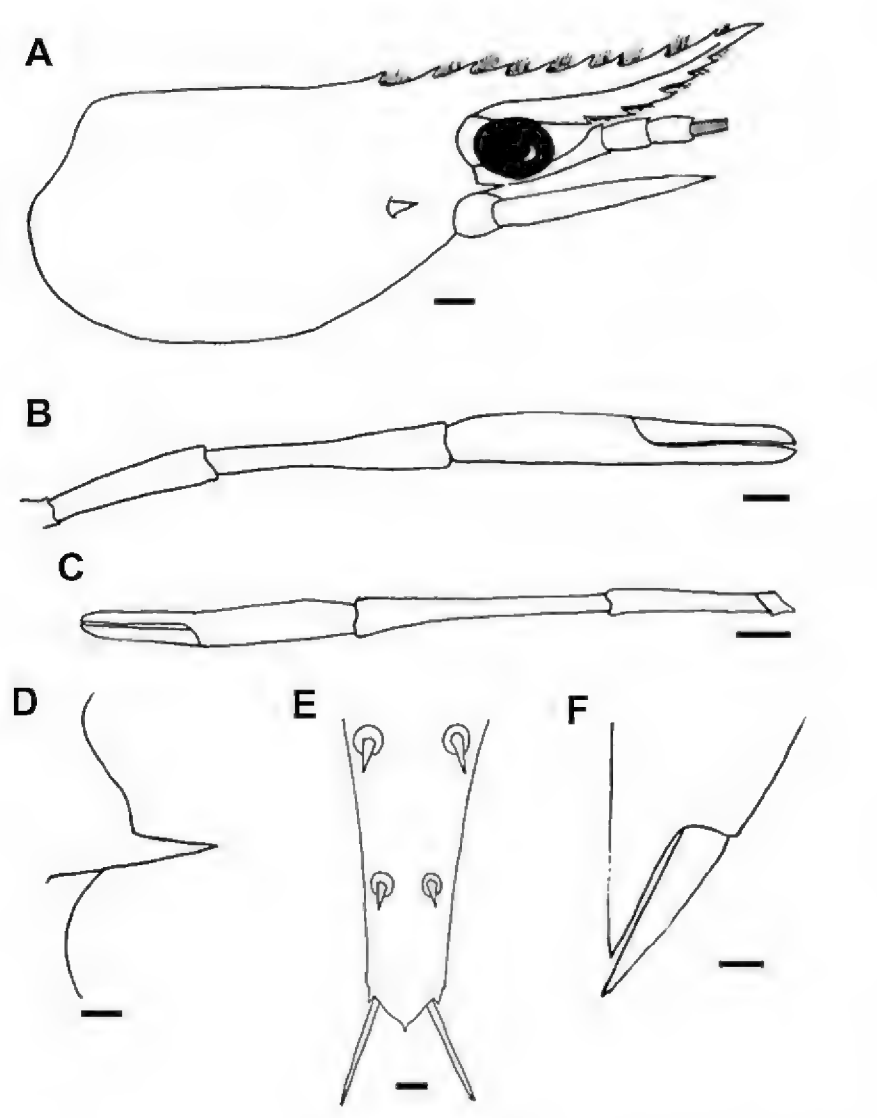

Figure 12. Schematic illustrations of *Macrobrachium equidens* (Dana, 1852). **A.** Carapace. **B.** Major second pereiopod. **C.** Minor second pereiopod. **D.** Postantennular margin. **E.** Telson. **F.** Mobile mesial spine. Scale bars: 1 mm.

Identification. Rostrum long, distinctly beyond end of scaphocerite, slightly upturned anteriorly, rostral formula: 2–4+8–10/4–7, without apical teeth; post-antennular carapace margin straight. Second pereiopod slender, equal in size, similar in shape; major second pereiopod with subcylindrical chelae, longer than carpus; carpus longer than merus; fingers not gaping. Movable spiniform setae on uropodal diaeresis longer than outer angle. Distal margin of telson with 1 pair of large spiniform setae. Pre-anal carina absent.

Distribution. *Macrobrachium equidens* occurs in the Indo-West Pacific, including Cameroon (Siméon et al. 2014) and Australia (Short 2004). In Indonesia, this species is distributed from Sumatra and Java to Ambon (see De Grave and Fransen 2011). This species has also been reported from Maros, South Sulawesi (Suhardjono et al. 2012).

Ecology. We found *Macrobrachium equidens* only in Peleng and Labobo islands. This species was collected together with *M. australe*, *M. latidactylus*, *C. brevicarpalis*, *C. serratirostris*, and *C. gracilipes*. The microhabitat of this species was macrophytes, leaf litter, and deadwood. The water temperature was 24 °C to 28 °C, DO was 5.66–8.3 mg/l, and pH was 7.0–8.3. Substrates were mud and sand.

Remarks. The rostrum of *M. equidens* is variable in form (Cai et al. 2004). Our specimens fit well with the description of this species by Dana (1852).

***Macrobrachium lar* (Fabricius, 1798)**

Figure 13A–F

Material examined. INDONESIA – **Central Sulawesi** • Bangkurung Island, Sungai Kanari; 01°54′54″S, 123° 03′06″E; 32 m elev.; 22.VI.18; Fazlur Rahman I. Tadeko leg.; 1 ♂ (cl 16.53 mm), MZB Cru. 5380; 2 ♂ (cl 19.33–32.37 mm), 1 ♀ (cl 18.66 mm), UTD Cru. 0157 – **Central Sulawesi** • Labobo Island, Mata Air Kotukan; 01°43′56″S, 123°18′17″E; 84 m elev.; 22.II.19; Puji Rahayu, Annawaty leg.; 12 ♂ (cl 5.42–23.66 mm); 26 ♀ (cl 3.37–18.76 mm), 2 ovig. ♀ (cl 4.80–20.75 mm), UTD Cru 0131 – **Central Sulawesi** • Labobo Island, Sungai Mata Air lamo; 01°40′55″S, 123°22′52″E; 45 m elev.; 22.II.19; Puji Rahayu, Annawaty leg.; 5 ♂ (cl 5.26–14.86 mm); 12 ♀ (cl 4.42–13.81 mm), UTD Cru 0134.

Identification. Rostrum short, reaching distal end of third segment of antennular peduncle, upturned anteriorly, rostral formula: 1+7/2–6; post-antennular carapace margin rounded. Second pereiopod slender, long, equal in shape, similar in size, all segments covered with spines; chelae longer than carpus with outer margin covered by densely spines; carpus shorter than palm with conical shape; fingers gaping, with 1 pair of large teeth both on proximal of cutting edges; Movable spiniform setae on uropodal diaeresis shorter than outer angle; preanal carina low; Distal margin of telson with 1 pair of large spiniform setae.

Distribution. *Macrobrachium lar* is widely distributed in the Indo-Pacific (Short 2004; Castelin et al. 2013). In

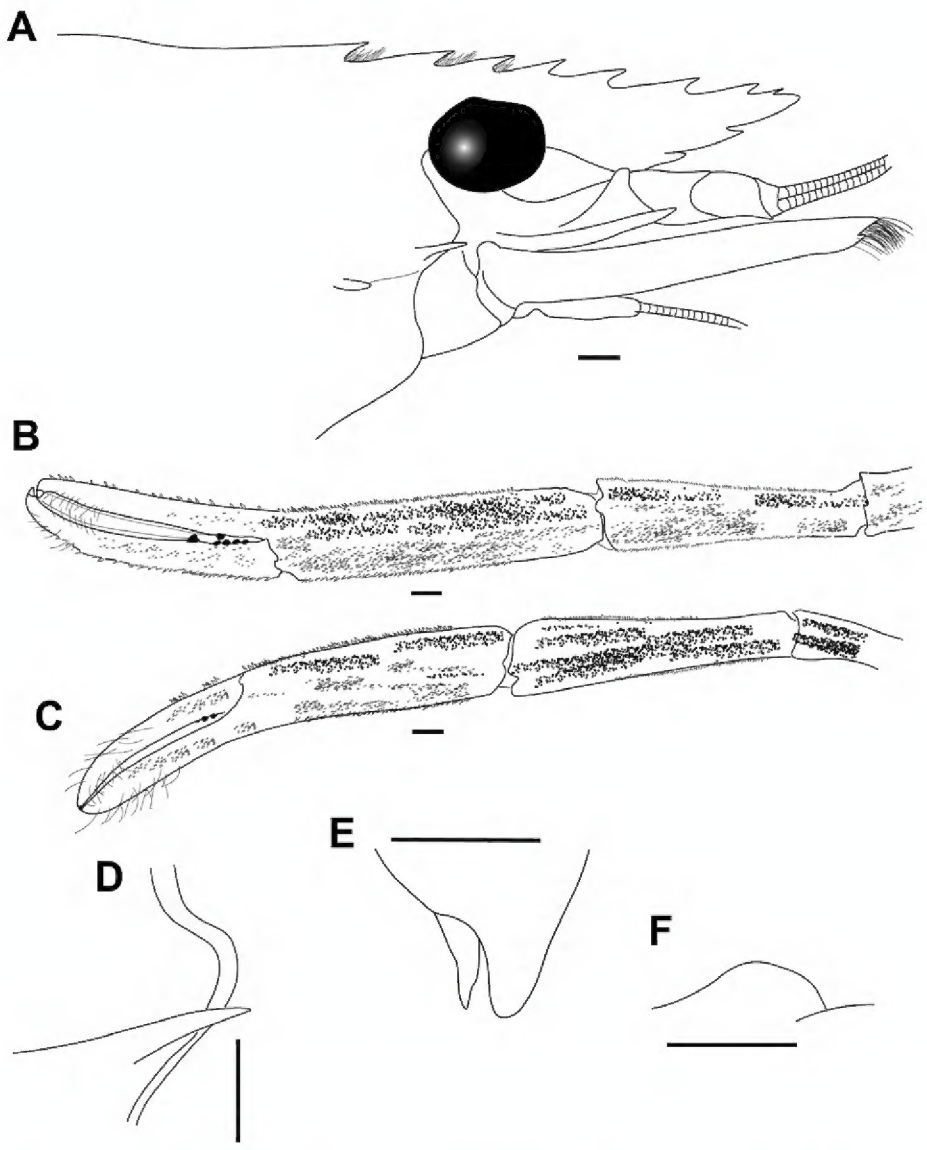

Figure 13. Schematic illustrations of *Macrobrachium lar* (Fabricius, 1798). **A.** Carapace. **B.** Major second pereiopod. **C.** Minor second pereiopod. **D.** Postantennular margin. **E.** Mobile mesial spine. **F.** Pre-anal carina. Scale bars: 1 mm.

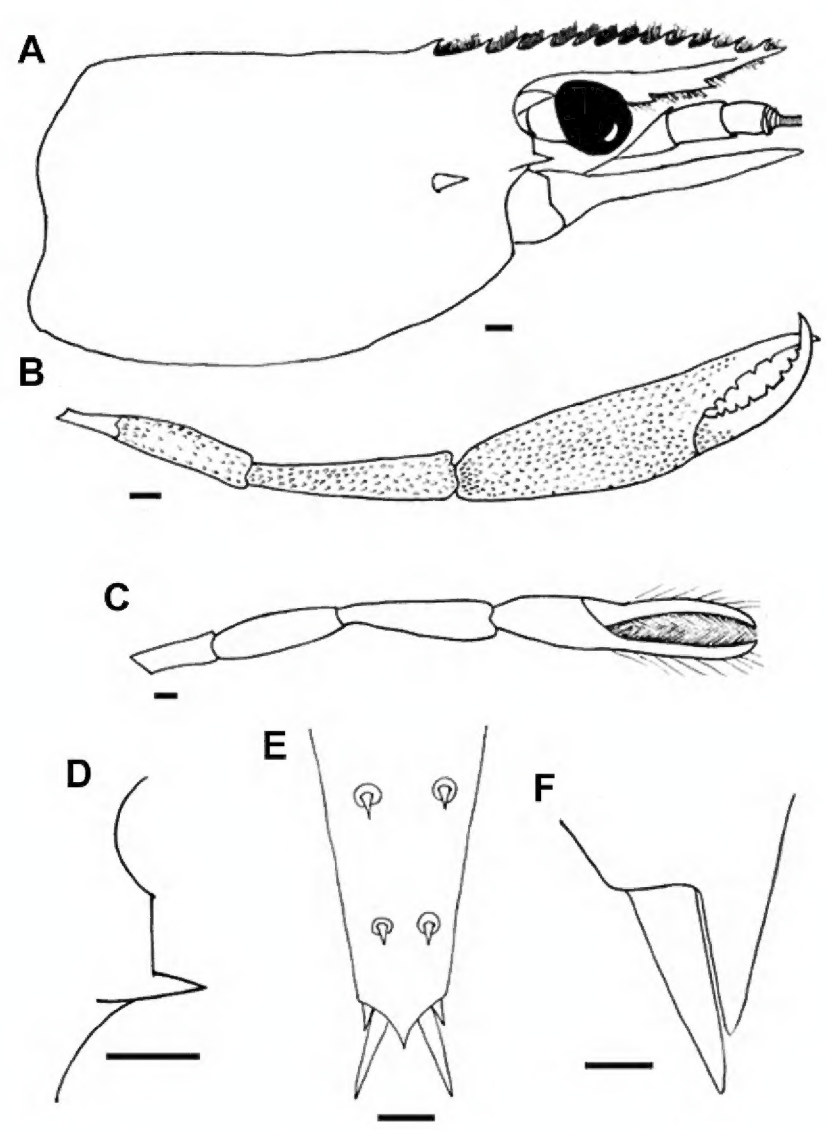

Figure 14. Schematic illustrations of *Macrobrachium latidactylus* (Thallwitz, 1891). **A.** Carapace. **B.** Major second pereiopod. **C.** Minor second pereiopod. **D.** Postantennular margin. **E.** Telson. **F.** Mobile mesial spine. Scale bars: 1 mm.

Indonesia, this spesies can be found from Java to Ambon (De Grave and Fransen 2011), including Halmahera (Cai and Ng 2001), and Sulawesi (Donggala) (Dwiyanto et al. 2018).

Ecology. We found *M. lar* only on Bangkurung and Labobo islands. This species was found with *C. serratirostris*, *C. typus*, and *C. weberi*. The microhabitat was macrophytes, dead wood, submerged plant roots, and under rocks. The water temperature was 27–28 °C, DO was 7.7–8.3 mg/l, and pH was 9.3–9.7. Substrates were mud and sand.

Remarks. Our specimens fit well with the original description of this species by Fabricius (1798) and several specimens described by Short (2004) from Australia but have a variation in their ventral teeth (2–6 vs. 2–4 in Short 2004).

Macrobrachium latidactylus (Thallwitz, 1891)

Figure 14A–F

Material examined. INDONESIA – **Central Sulawesi** • Peleng Island, Sungai Bukoti Mbombol; 01°25′00″S, 123°14′30″E; 13 m elev.; 05.III.2017; Nur Hidayah E. Lapasang leg.; 4 ♂ (cl 16.04–18.05 mm), MZB Cru. 5381; 37 ♂ (cl 5.94–18.67 mm), 1 ♀ (cl 13.36 mm), UTD Cru. 0029 – **Central Sulawesi** • Labobo Island, Mata Air Batambean; 01°40′42″S, 123°21′28″E; 13 m elev.; 22.II.2019; Puji Rahayu, Annawaty leg.; 3 ♂ (cl 4.15–5.65 mm), 1 ♀ (cl 6.43 mm), UTD Cru. 0126.

Identification. Rostrum short, reaching to or sometimes beyond end of third segment of antennular peduncle but never beyond tip of scaphocerite, dorsal margin convex, rostral formula: 3–5+10–14/2–4, without apical teeth. Post-antennular carapace margin straight. Second pereiopod unequal in size and dissimilar in shape; carpus shorter than chelae and palm but longer than merus; major chelae broad with palm compressed, fingers denticulate on cutting edges with gap; minor chelae slender, fingers with long stiff setae. Movable spiniform setae on uropodal diaeresis longer than outer angle. Telson glabrous, margin of telson with 1 pair of large spiniform setae. Pre-anal carina absent.

Distribution. *Macrobrachium latidactylus* occurs in Japan (Cai and Ng 2001), Thailand (Cai et al. 2004), South China, Malaysia, and the Philippines, as well as Australia (Short 2004). This species was first described by Thallwitz (1891) based on type specimens from Sulawesi. It has also been reported from Lesser Sunda Islands (De Man 1892) and Halmahera (De Man 1902; Cai and Ng 2001) to Papua. In Sulawesi, this species has a wide distribution from South Sulawesi, Morowali (Laewa et al. 2018) to Pare-Pare and Maros (De Grave and Fransen 2011).

Ecology. We found *M. latidactylus* only on Peleng and Labobo islands. It was collected with *M. equidens*, *M. australe*, *C. brevicarpalis*, *C. serratirostris*, *C. gracilipes*, and *C. typus*. The microhabitat was macrophytes, sago roots, leaf litter, and dead wood. The water temperature was 25–28 °C, DO was 5.2–8.8 mg/l, and the pH

was 7.0–9.3. Substrates were mud and sand.

Remarks. The rostrum dentition and carpus of our specimens of *M. latidactylus* agree well with the original description of North Sulawesi type specimens (Thallwitz 1891).

Discussion

Although Sulawesi Island has been well studied for its freshwater shrimps, many areas are still unexplored due to their remoteness, a lack of time, and logistics. Here, we report 12 species from nearby islands in eastern Sulawesi. As most of these species bear many small eggs, which suggest a prolonged larval stage (amphidromy; see Vogt 2013) and greater capacity to disperse, it is possible that these species have wide distributional ranges (Fujita et al. 2016).

Of the 12 species, only one, *Caridina brevidactyla*, is reported here from Sulawesi and its surrounding islands for the first time. This species has a relatively small egg size (0.37–0.47 mm × 0.22–0.30 mm; de Mazancourt et al. 2018a) and an extended larval stage which suggests that this species is capable of dispersal across the sea. This species has previously been reported from Halmahera, about 500 km east of Sulawesi (Cai and Ng 2001). The sea currents between Sulawesi and Halmahera and duration of the larval stage might support the dispersal of this species between islands. Larval development of *Caridina* species correlates with their wide distributions (Fujita et al. 2016). Sulawesi and Halmahera are also relatively near to each other, and they share other amphidromous species, such as gobiid fishes (Gani et al. 2021).

The Banggai Archipelago has an endemic species, *C. thomasi*, from Alani, Peleng Island (von Rintelen et al. 2008) that we did not find in our study. For further study, sampling should focus not only on lowland areas but also on highlands in the island's core, where there is no direct access to the sea or estuary. Another small island that contains endemic *Caridina* is Buton Island near Southeast Sulawesi (von Rintelen and Klotz 2013).

The highest diversity of freshwater shrimps is found on Labobo Island (eight species). The land area of this island is only 80 km^2, the smallest island in our study. However, this island formed from the same original microcontinent as the other island, Banggai-Sula, which has a similar geological history (Watkinson et al. 2011). The proportion of amphidromous species inhabiting river systems in oceanic islands cannot be directly related to island size (but see Bass 2003) because many factors influence its occurrence, including distance (Benstead et al. 2009; de Mazancourt et al. 2018b), altitude (de Mazancourt et al. 2020), and geological processes (de Mazancourt et al. 2020).

Banggai Archipelago contained a smaller number of freshwater shrimp species than neighboring Halmahera Island (17,780 km^2), which hosts 17 species (Cai and Ng 2001). However, despite the small size of the Banggai Archipelago (about 3,000 km^2 overall), the number of freshwater shrimp species is still relatively high and diverse. Anthropogenic activities in the small islands, such as using poison to catch fish, contaminating water bodies by dumping waste and pesticides, converting natural waterfalls for recreation, and damming waterflows, likely decrease shrimp populations. For this reasons, local legislation should protect to the habitats of these species. The ecology of freshwater shrimps should be studied in order to conserve these species and the ecological services they provide.

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Authors' Contributions

Conceptualization: AA. Data curation: NHEL, HH, DD, AA, PR. Visualization: NHEL, DD, HH. Writing – original draft: DD, PR, FRIT, HH, NHEL. Writing – review and editing: AA.

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